

Corrector Alignment: AP Requirements

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Summary

AP requirements for multi-layer correctors

- RHIC AP Requirements
measurements: method
data (offset, roll)
- LHC estimates
simulation: offset
roll angle

RHIC and LHC IR corrector schemes

• RHIC:	C1	b1/a1	b4	b5	b6
	C2	a2	a3	a4	a6
	C3	b1/a1	b3	b4	b6
• LHC:	MCX1	b1+a1	b4	b5	a5
	MCX2	a2	a3	a4	a6
	MCX3	b1+a1	b3	b6	

RHIC correctors:

arc: 420 units 8cm aperture (264 4-layers, 156 1-layer)

IR: 72 units 13cm aperture (all 4-layers)

all powered by 50A supplies (only dipole layers powered during
Phase 1 commissioning this summer)

RHIC alignment AP requirements

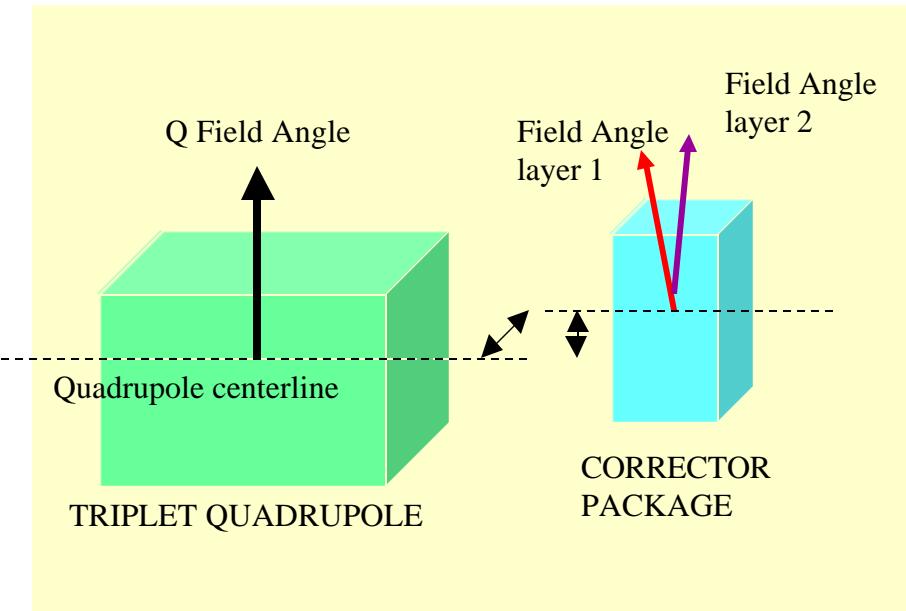
CQS packages (arc)

- offset
CQS103 3mm: 50A dec ->20A oct
gamma-T offset < 1 mm
all others offset < 2 mm
- roll
dipole: 3.3+3.0 mrad negligible
n. quad: -4.7+4.3 mrad negligible
sk.quad: -2.9+5.4 mrad tolerable
octupole: 20 mrad -> skew ~10%
layer roll < 20 mrad
- longitudinal
negligible

CQ packages (IR)

- offset
calculation of feed-down:
all layers < 1 mm
- roll
calculation of rotation order by
order:
all layers < 5 mrad
- longitudinal
negligible

Alignment of corrector package



- Assemble corrector package (CP) to the quadrupole (Q)
- Measure **Q Field Angle** and fit **Q centerline** (which determine installation)

- Measure **CP center**. CP realigned only if outside specification (1mm)
- measure **CP Field Angle** for every layer. Rotate single layer Field Angle to align it to Q Field Angle
- same coordinate system (fiducials on magnet and gravity)
- all measurements **warm**
- precision of the initial mechanical positioning:
offset ~ 0.1mm
roll ~ 0.5 mrad
- **hysteresis** effects on transfer functions of layers (single and multi-layer)

LHC IR correctors - effect of roll

Reduction of b_n strength
through b_n tilt
[% of original b_n value]
 $b_n = b_n \cos n\theta$

Multipole order	0.5 mrad	1 mrad	2 mrad	5 mrad
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.01
4	0.00	0.00	0.00	0.02
5	0.00	0.00	0.00	0.03
6	0.00	0.00	0.01	0.04

Creation of a_n strength
through b_n tilt
[% of original b_n value]
 $a_n = -b_n \sin n\theta$

Multipole order	0.5 mrad	1 mrad	2 mrad	5 mrad
1	0.05	0.10	0.20	0.50
2	0.10	0.20	0.40	1.00
3	0.15	0.30	0.60	1.50
4	0.20	0.40	0.80	2.00
5	0.25	0.50	1.00	2.50
6	0.30	0.60	1.20	3.00

Results confirmed by
simulation: no noticeable
effect for $\theta < 20$ mrad

LHC IR Correctors - simulation of offset

- LHC lattice Version 5.1
- FNAL HGQ errors Version 2.0
- KEK HGQ errors Version 3.0
- Corrector scheme: baseline selected at BNL Workshop May 99

- Calculate correction scheme for 10 different error distributions
- Track (1000 turns) and calculate **dynamic aperture for the baseline** case, without corrector misalignment
- Add random distribution of offset errors to the corrector packages (all layers shift coherently)
- Track (1000 turns) ten seeds and calculate **dynamic aperture with corrector misalignment**
- Compare results

LHC IR Correctors: effect of offset

$\Delta x = \Delta y = 0$				$\Delta x = \Delta y = 1\text{mm}$			
ax/ay	average	rms	minimum	ax/ay	average	rms	minimum
0.4	11.90	0.54	11	0.4	11.70	1.00	10
0.25	11.70	1.00	10	0.25	11.30	1.27	9
0.50	11.80	0.75	10	0.50	11.60	1.02	10
0.75	11.90	0.70	11	0.75	12.10	0.54	11
0.90	12.70	0.64	12	0.90	12.50	0.64	12

rms $\Delta x = \Delta y = 2\text{ mm}$			
ax/ay	average	rms	minimum
0.4	11.20	1.17	9
0.25	11.00	1.10	9
0.50	11.10	1.22	9
0.75	11.80	0.75	11
0.90	12.40	0.92	11

From results reported at BNL Workshop (Fischer, et.al) for the same configuration there is no effect on the dynamic aperture for $\Delta x=\Delta y=0.5\text{mm rms}$

Conclusions

- The effect of corrector **offset** on the quality of IR correction (and hence dynamic aperture at collision) is noticeable. Transverse alignment of the corrector package center should be kept < **0.5mm**
- The IR correction scheme is insensitive to **rotation** of IR correctors. No effect due to rotation of nonlinear layers has been seen for roll < 20 mrad. It would however advisable to keep layer alignment within **5 mrad** (RHIC experience, effect on linear corrections?)
- In the next Phase of **RHIC Commissioning**, starting in December 1999 the IR correctors will be powered. Experience, experiments, etc.